Could Combining Growth Mindset and Task Complexity Affect Motivation, Cognitive Load, and Performance? An Experimental Study.

De Koning, Nick

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Zou het Combineren van Growth Mindset en Taakcomplexiteit Invloed Kunnen Hebben op Motivatie, Cognitieve Lading en Prestaties? Een Experimentele Studie.

Nick de Koning

Master Educational Sciences
Open University

Course name and number: Master thesis – OM9906
Name supervisor: Kate Xu, PhD
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Summary

Primary school students can be difficult to motivate. This can result in low readiness to solve problems that require effort investment, which can in turn result in less effective teaching and learning outcomes. Children's mindset of intelligence could play a role in their motivation and learning. When a learner has a fixed mindset, intelligence is perceived as something that cannot be changed. While someone who has a growth mindset sees intelligence as something malleable that can be developed. Students who have a fixed mindset are likely to stop learning when they encounter a problem, while students who have a growth mindset are likely to demonstrate perseverance and invest more mental effort.

Previous research in cognitive load theory suggests that the effectiveness of certain instructional methods can differ for tasks of varying complexity. It is assumed that the human working memory load is limited thus the complexity of the instructional materials can have an impact on the learning process. Greater complexity requires higher mental effort in the learning process. It is thus possible that differences in complexity can affect learning depending on the learner's mindset and the corresponding view on effort. The goal of this study was to inform the role of stimulating growth mindset for primary school student learning and improve understanding of its impact on motivation, cognitive load, and performance when solving problems of varying complexity.

A randomized controlled experiment was used to test the hypotheses, based on a sample of 118 children from group 7 and 8 (aged 10 to 13) of two primary schools. The study consists of four groups representing two between factors: 1. growth mindset vs. control condition; and 2. low task complexity vs. high task complexity. After participants worked on either a growth mindset or control task, they learnt probabilities through one of two videos that contained an instructional message of either low- or high complexity.

The effects of growth mindset and complexity were investigated on attribution, achievement goal orientation, cognitive load and performance. While the growth mindset intervention did significantly improve the experienced growth mindset in the experimental conditions, no evidence was found for an effect on motivation (through attribution and achievement goals), cognitive load, and performance. These findings are comparable with some of the earlier studies on adolescents and university students. The results of the present study indicate that effect of growth mindset intervention remains inconclusive.

The complexity intervention did not have an effect on experienced cognitive load, indicating a possibility that the difference between the low and high complexity condition was not big enough to be detected from the current sample, or that self-reported measures might not be an accurate reflection of the actual cognitive load. Although the designs of the mindset materials and the task complexity closely followed theoretical guidelines and previous research, it is possible that the designs can be further improved in future research. Additionally, further research is needed into the effects of growth mindset on children of a lower socioeconomic background, as the current sample consist of mostly children from a higher socioeconomic background.

Keywords: Growth Mindset, Task Complexity, Cognitive Load, Attribution, Achievement Goal Orientations, Performance

Samenvatting

Het kan moeilijk zijn om basisschoolleerlingen te motiveren. Deze lage motivatie kan zich laten zien doordat leerlingen een lage bereidheid tonen om problemen op te lossen die om doorzettingsvermogen vragen, wat zorgt voor minder effectief lesgeven en lagere leeruitkomsten. De mindset van kinderen op het gebied van intelligentie kan een rol spelen bij motivatie en leren. Wanneer een leerling een fixed mindset heeft, wordt intelligentie gezien als iets dat niet kan worden veranderd. Terwijl iemand met een growth mindset, intelligentie ziet als iets dat kan worden ontwikkeld. Leerlingen met een fixed mindset zullen waarschijnlijk stoppen met leren wanneer ze een probleem tegenkomen, terwijl leerlingen met een growth mindset waarschijnlijk doorzettingsvermogen tonen en zich mentaal meer inspannen.

Eerder onderzoek naar cognitive load theory suggereert dat de effectiviteit van verschillende instructiemethodes verschilt voor taken van verschillende complexiteit. Het wordt aangenomen dat de menselijke werkgeheugencapaciteit beperkt is. Daardoor kan de complexiteit van instructiematerialen een impact hebben op het leerproces. Grotere complexiteit vereist meer mentale inspanning bij het leerproces. Het is daarom mogelijk verschillen in complexiteit het leren beïnvloeden en dat dit afhankelijk is van de mindset van de leerling en hoe de leerling naar doorzettingsvermogen kijkt. Het doel van deze studie was om de rol van het stimuleren van growth mindset bij basisschoolleerlingen te onderzoeken en het begrip van de impact daarvan op motivatie, cognitieve belasting en prestaties bij het oplossen van problemen van verschillende complexiteit te vergroten.

Dit onderzoek is een gerandomiseerd gecontroleerd experiment gebaseerd op een steekproef van 118 kinderen uit groep 7 en 8 (van 10 tot 13 jaar) van twee basisscholen. De studie bestaat uit vier groepen die twee factoren vertegenwoordigen: 1. growth mindset vs. de controleconditie; en 2. lage taakcomplexiteit vs. hoge taakcomplexiteit. Nadat deelnemers aan een growth mindset of controletaak hadden gewerkt, leerden ze over kansberekening doormiddel van één van twee video’s met een instructie van lage of hoge complexiteit.

De effecten van growth mindset en complexiteit werden onderzocht op attributie, achievement goal oriëntations, cognitieve belasting en prestaties. Hoewel de growth mindset interventie de ervaren growth mindset in de experimentele conditie significant verbeterde, werd geen bewijs gevonden van een effect op op motivatie (door attributie en achoevement goals), cognitieve belasting en prestaties. Deze bevindingen zijn vergelijkbaar met enkele eerdere onderzoeken onder adolescenten en universiteitsstudenten. De resultaten van de huidige studie geven aan dat het effect van de growth mindset interventie niet duidelijk was.

De complexiteitsconditie had geen effect op de ervaren cognitieve belasting, wat erop duidt dat het verschil tussen de lage en hoge complexiteitsconditie niet groot genoeg was om te worden waargenomen in de huidige steekproef of dat de meetinstrumenten waar zelfrapportage werd gebruikt geen precieze meting waren van cognitieve lading. Hoewel het ontwerp van de materialen voor mindset en taakcomplexiteit nauw aansluiten bij de theoretische richtlijnen en eerder onderzoek is het mogelijk dat deze in toekomstig onderzoek kunnen worden verbeterd. Daarnaast is verder onderzoek nodig naar de effecten van growth mindset op kinderen met een lagere sociaaleconomische achtergrond, gezien de huidige steekproef voornamelijk bestond uit kinderen met een hogere sociaaleconomische achtergrond.

Trefwoorden: Growth Mindset, Taakcomplexiteit, Cognitive Load, Attributie, Achievement Goal Orientations, Leerresultaten

1. Introduction

Primary schools in the Netherlands are struggling to motivate their students to learn (Inspectie van het Onderwijs, 2017). This results in many Dutch students having a low readiness to engage with and work on solving especially complex problems that require effort (OECD, 2016). Whilst some students thrive while working on challenging problems, others fear it. Often, these two ways of thinking about learning can be linked to either a fixed mindset or a growth mindset. According to mindset research (Dweck, 2006, 2017), students have a fixed mindset if they stop learning when they encounter a problem. They have a growth mindset if they see problems in learning as challenges to defeat.

These differences in thinking about challenges can have a profound impact on the motivation and outcomes of learning. When a growth mindset is promoted, students seem to focus more on learning goals that aim to mastery knowledge. It could affect motivation by altering attributions and goal orientations (Haimovitz & Dweck, 2017; Yeager & Dweck, 2012). This can have positive effects on learning by potentially reducing perceived cognitive load and increasing performance (Haimovitz & Dweck, 2017; Yeager & Dweck, 2012).

Much of the research currently done on growth mindset is focused on improving achievement-related motivation or performance outcomes measured by grades or exam scores. There is a gap in knowledge about how a growth mindset influences factors during the learning processes such as perceived cognitive load. When looking at learning through the lens of instructional design and cognitive load theory it could be theorized that mindset influences the accessibility and activation of working memory, which in turn affects the process of knowledge being stored in long-term memory. This could mean that learners with a growth mindset experience less cognitive load, in particular when a task is more complex.

Furthermore, very few previous studies have examined the effect of growth mindset in children. This study aims to bridge this gap in the literature by informing the effectiveness of growth mindset interventions for learning in primary school students. It also aims to increase the understanding of how growth mindset affects experienced cognitive load while children learn new knowledge under different levels of task complexity.

1.1 Theoretical framework

This section on theoretical framework will first elaborate on growth mindset, then connect this to research on learning and motivation (achievement goal orientation and attribution), and lastly make a connection with cognitive load theory.

1.1.1 Theories of Intelligence: a Fixed or Growth Mindset

People can have implicit theories about the malleability of their traits. These are used as an implicit scheme to make predictions and judgments about daily events without someone necessarily being aware that this happens. Implicit theories revolve around different traits like personality or ability. In this study, we focus on learning and thereby implicit theories about intelligence. These implicit theories can be divided into a spectrum with growth and fixed mindset on either end. At the extreme ends of mindset, growth and fixed mindsets can be seen as two different worlds where challenges and setbacks have different meanings (Dweck, 2006, 2017; Yeager et al., 2014).

When a learner has a fixed mindset, intelligence is seen as something that cannot be changed (Dweck, 2006). The goal of the learner is mostly to look smart. Everything that happens during learning is seen as something that measures ability. This is seen as a threat because it produces a judgment about the intelligence of the learner. When setbacks happen, a lack of intelligence is assumed. Learning is then stopped, this to prevent more humiliation.

A growth mindset is a different way of thinking in which learners see intelligence as something malleable that can be developed (Dweck, 2006). Then, the goal is to learn new things. Challenges, setbacks, measurements, and effort are seen as helpful tools to accomplish this goal. Learners with this implicit theory don't see setbacks as a threat and don't stop learning when they encounter them. Instead, setbacks only motivate them to alter their strategy and work harder.

Most people are somewhere in between of having a growth or fixed mindset. Mindset tends to be a somewhat stable trait, but it can be malleable to change either slowly over time or through specific interventions (Dweck, 2017; Robins & Pals, 2002). Sometimes big life events or long exposure to certain behaviors can also have an impact on obtaining one of the two mindsets.

1.1.2 Mindsets of Children

Research has suggested that mindsets affect children in a different way than adults (Dweck, 2002, 2003). At ages below 6, implicit theories do not yet affect behavior (Cain, Kathleen & Dweck, 1995; Dweck, 2002, 2003), this tends to start when children get to the age of 7 to 8 years old. They then start to compare their ability with others (Bempechat, 1991; Dweck, 2002, 2003). At about 10 to 12 years old, this results in endorsing either a more growth or fixed mindset (Dweck, 2002, 2003).

There are relatively few studies that have examined the effect of growth mindset interventions in children younger than 13 (Sisk et al., 2018). In a randomized experimental study, Mueller & Dweck (1998; Study 1) studied growth mindset in 128 children of 10 to 12 years old. Growth mindset was elicited using effort praise. It was reported that the children who received effort praise, overwhelmingly endorsed learning goals instead of performance goals. These children also attributed poor performance more to low effort than low ability. While these results seemed promising, they could not be replicated in subsequent research (Li & Bates, 2017). In both studies, there was no manipulation check reported to assess if mindset was affected by differences in praise.

Furthermore, it is doubtful that effort praise is a reliable way of inducing growth mindset, producing different results than intended. Most later studies have therefore used either a task or workshop about the malleability of the brain. This seems the more promising path to inducing growth mindset in a reproducible way (Burnette et al., 2018; Yeager et al., 2019). For example, Blackwell et al. (2007; Study 2) induced growth mindset in a random half of a sample of 91 children of 13 to 14 years old, using multiple workshops on the malleability of the brain. The experimental condition saw a significant positive change in the endorsement of growth mindset (Cohen's d = 0.66). There was no significant difference in the control group. While mathematics grades of students in the control group decreased over time, grades of students in the experimental condition improved after the intervention. This fuels the belief that a growth mindset intervention that teaches about the malleability of the brain can be successful in promoting learning.

1.1.3 Mindsets and Academic Achievement

There has been a substantial amount of research demonstrating the positive impact implicit theories have on learners. While many studies suggest that a growth mindset is positively associated with academic achievement, in meta-analyses the overall effect is small. In a meta-analysis of 85 studies, Burnette et al. (2013) found a small correlation (r = .10) between mindset and achievement. This was confirmed in a later meta-analytic review study by Sisk et al. (2018). This study reported results from two meta-analyses. The first meta-analysis of 129 studies found a small correlation (r = .10; Study 1), the second meta-analysis consisting of 29 intervention studies confirmed this outcome (Cohen's d = 0.08; Study 2).

Both meta-analyses focused on achievement measures like grades or exam scores. These measures do not account solely for learning but are also affected by other factors. For example, grades are affected by prior knowledge (Hailikari et al., 2008). The effects of interventions may be diminished because of attribution and participants' disengagement with the intervention materials (Hulleman & Cordray, 2009; Yeager et al., 2019). These factors could be controlled in an experimental setting where prior knowledge and participant engagement could be screened more accurately.

Measuring immediate knowledge retention and transfer can be a better reflection of the learning process. In a randomized experimental study based on 138 high school students, Xu et.al. (2020) induced growth mindset in half of the participants. Participants in the experimental and control condition had to perform a learning task. The students in the growth mindset condition experienced lower cognitive load (Cohen's d = -0.32 for intrinsic load; Cohen's d = -0.66 for extraneous load) than students in the control condition. Students in the experimental condition also outperformed the control condition on knowledge retention (Cohen's $d = 0.33$) and transfer (Cohen's $d = 0.39$). These results indicate that growth mindset can significantly enhance learning during a specific learning task.

1.1.4 Mindsets and Achievement Goal Theory

While there is evidence that mindsets influence learning motivation (De Castella & Byrne, 2015; Dweck, 2003; Rhew et al., 2018), how motivation is affected can be explained through achievement goal theory (Cury et al., 2006; Diaconu-Gherasim et al., 2019). According to Ames (1992, p. 261) an achievement goal 'defines an integrated pattern of beliefs, attributions, and affect that produces the intentions of behavior and that is represented by different ways of approaching, engaging in, and responding to achievement activities.' Four different patterns can be adopted: students can have (1) a mastery-approach strategy and want to increase their competence; (2) a mastery-avoidance strategy and want to avoid a decrease in competence; (3) a performance-approach strategy and strive to demonstrate competence; (4) a performance-avoidance strategy and strive to avoid demonstrating incompetence (Korn et al., 2019).

Whether someone embraces either mastery or performance goals can be predicted by their adopted implicit theory. When students endorse a growth mindset, they are more likely to adopt a mastery goal orientation (Blackwell et al., 2007; Burnette et al., 2013), these can be either mastery-approach or mastery-avoidance goals. A fixed mindset usually results in greater adoption of performance-approach or performance-avoidance goals (Cury et al., 2006).

1.1.5 Mindsets and Attribution Theory

Mindsets are not only the basis for achievement goal orientation, but are also the mental framework affecting how certain causes are attributed to failure or success when learning (Hong et al., 1999). This can be explained through attribution theory, which proposes a mental framework that people use to attribute importance to an unexpected negative or important event (Weiner, 1979, 2010, 2018). Among the main attribution factors used in experimental research are ability and effort (Hau & Salili, 1993; Weiner, 2010).

The way someone weighs controllability when attributing has consequences for motivational behavior (Weiner, 2010). Attribution to controllable causes is particularly helpful when failure arises because then failure is seen as something that can be fixed. Indeed, Hong et al. (1999) has argued that people with different implicit theories define ability in different ways. Someone with a fixed mindset sees ability as something that measures intelligence, while someone with a growth mindset perceives ability as the current skill they have on a task. For them, it says nothing about their intelligence as a whole. This also means that someone with a growth mindset won't see ability as uncontrollable, but rather as something that can be improved by putting in more effort or time (Dweck et al., 1995; Dweck & Leggett, 1988; Hong et al., 1999).

How people attribute can affect their perceptions of some cognitive processes that are central to learning. For example, task difficulty and effort are both major controllable causes in attribution theory and can prompt an increase in cognitive load (Soriano-Ferrer & Alonso-Blanco, 2019). In this way growth mindset could be connected to cognitive load theory, through motivation (as attribution).

1.1.6 Mindsets and Cognitive Load Theory

A new area of interest in mindset research is the possible effect that implicit theories can have on the learning process itself. To be able to examine this, a clear understanding of the workings of learning is needed. Sweller et al. (1998) put forward the foundations for the cognitive load theory. This theory is widely used for understanding how effective instructional design can be developed, taking into account the inner workings of the brain. The cognitive load theory proposes that instruction and learning should be constructed based on assumptions of limited working memory and an unlimited long-term memory (Sweller et al., 2019).

The main concern of cognitive load theory is to manage the instructional design element to maintain the ease with which information is processed in working memory (Sweller et al., 1998, 2019). Working memory is limited when dealing with novel information. It is capable of holding about seven elements of information at the same time (Miller, 1994; Sweller et al., 2019). To organize, compare, contrast, or process information in any other way, parts of those seven elements are also needed (Sweller et al., 1998). This means that even seemingly simple cognitive activities can prompt a cognitive overload. While the working memory is overloaded, it cannot be used for efficient processing and storing of information (Van Merriënboer & Sweller, 2005). The span of working memory and thus someone's ability to handle cognitive overload can differ between people (Chen et al., 2015).

Working memory load can be incurred either by intrinsic or extraneous cognitive load. Intrinsic cognitive load is determined by the intrinsic nature of the complexity of the materials that need to be learned. Extraneous load is determined by the way those materials are being presented. When there is either too little or too much load as a result of intrinsic and extrinsic load, learning can be hindered (Sweller et al., 1998, 2019; Van Merriënboer & Sweller, 2005). When learning does happen, germane cognitive load occurs. Germane load isn't imposing a load in its own right. It instead functions by redistributing working memory resources from extraneous load to reducing intrinsic load (Sweller, 2010; Sweller et al., 2019).

Changing the amount of load put on working memory can be done in different ways. Extraneous load can be altered by changing the presentation of learning materials (Chen et al., 2015; Sweller et al., 2019). Altering the amount of intrinsic load is harder, but not impossible. It is determined by the interaction between the expertise level of the learner and the nature of the materials that need to be learned. While a novice may find certain learning materials very hard, an expert in the same field can find the same materials very easy to understand (Van Merriënboer & Sweller, 2005). This can be explained in terms of task complexity. For a low complexity task, few elements have to be kept in working memory, whilst for high complexity tasks, multiple elements have to be manipulated. Prior knowledge of the person working on a certain task also has to be accounted for (Sweller et al., 1998).

There are previous studies that looked at the effect of low and high intrinsic load tasks on other learning activities like direct instruction and invention (Chen et al., 2015). These tasks represent different learning goals and are not inherently comparable with the current study. To date, there is still a lack of research that directly examines the instructional effect of varying the level of element interactivity.

1.1.7 Present study

Moreno and Mayer (2007) have suggested that learners sometimes fail to engage in learning due to a lack of motivation, even when enough cognitive capacity is available. In contrast, it seems that when motivating factors, such as topic interest (Skuballa et al., 2019) and positive emotions (Brom et al., 2018) are perceived, task difficulty decreases. This could also imply a decrease in intrinsic load.

Mindset theory could be a promising way of explaining why motivation could influence cognitive load. First, adopting a growth mindset changes the way learners attribute their failures and successes. Learners with a growth mindset attribute more to effort instead of task difficulty (Dweck & Master, 2008) because effort is within the learner's control and contribute to the development of knowledge and skills. This can point to a decrease in intrinsic and extraneous load and, thus an increase in germane load. Also, growth mindset encourages learners to adopt a mastery goal orientation and engage more actively in learning (Dweck & Master, 2008), and in that way could increase germane load.

The effect of growth mindset can also be affected by the level of task complexity, which is represented in terms of element interactivity. It is possible that when element interactivity does not exceed the capacity of the learner, the learner can handle the task with sufficient motivation and engagement, irrespective of their mindset. Whereas when the task is more complex and the learner's cognitive capacity is under higher pressure, the effect of having a growth mindset on perceived cognitive load (and therefore opportunity to continue learning) may be larger.

In conclusion, it is suggested that a growth mindset may redirect working memory resources through effort attributions and a mastery goal orientation from intrinsic and extraneous load to germane load, and this effect may be particularly prominent for tasks of high complexity/element interactivity. In order to test these suggestions, the present study will examine the effect of growth mindset intervention on grades 7 and 8 primary school children's motivation, cognitive load perceptions, and learning performance concerning tasks of high and low complexity.

1.2 Hypotheses

The present study aims to demonstrate this in an experimental setting. Instead of a general research question, hypotheses are formulated that are based on the theoretical framework that is described in this study. The combination of these theory driven hypotheses is the basis of this study:

1. Hypothesis 1: Participants in the growth mindset condition will report a higher growth mindset and wrote more about 'effort' and 'persistence' than learners in the control condition.
2. Hypothesis 2: The participants in the growth mindset condition will score higher on mastery-approach and mastery-avoidance and lower on performance-approach and performance-avoidance than participants in the control group.
3. Hypothesis 3: Participants in the growth mindset condition will have a lower attribution on intelligence than the control condition and a higher attribution on effort than the control condition.
4. Hypothesis 4: For cognitive load, in terms of main effects, the growth mindset condition participants will report lower cognitive load and that the low complexity group will report lower cognitive load. For the interaction between growth mindset and task complexity, the participants who are in growth mindset and higher interactivity group are expected to report lower cognitive load than those in the high complexity control condition.
5. Hypothesis 5: For learning performance, the growth mindset condition will have higher performance, the main effect on task complexity might show that low complexity group will have higher performance. For the interaction, the participants who are in growth mindset and high complexity group will report higher performance than those in the high complexity control condition.

2. Method

The design of the present study is a fully randomized experimental, two-way between-subjects design. There are two independent variables. The first one is the growth mindset or control condition: the participants will either be in the experimental condition and work on a growth mindset task or will be in the control condition and work on a comparable reading and writing task that does not promote growth mindset. The second independent variable is the low- or high-complexity task, the content of which will differ by the estimated element interactivity of the task. All questions in this research will be answered through data-collection with questionnaires.

2.1 Participants

The participants were recruited from two schools in the province of North-Holland in the Netherlands. Headmasters from both schools have consented to take part in this study. Parents have given consent for their child taking part as well. A total of 118 students from grades 7 and 8 took part in the study. Each participant was randomly assigned to one of the four experimental groups. The participants were randomly split into a condition that will perform the low or high intrinsic load tasks across growth mindset or control conditions. From the participants, 55,1% (n = 65) were female, while 44,9% (n = 53) were male. The participants were randomly assigned to one of four conditions: growth mindset-high complexity (n = 31), growth mindset-low complexity (n =29), control-high complexity (n = 29), or control-low complexity (n = 29). One participant in the control-low complexity condition stopped early with the experiment, the data up until that point was used for analysis.

2.2 Materials and Measures

All the materials used in the experiments were translated to Dutch and adapted for the current sample. The translations were checked by two bilingual speakers. Complete information of the study materials is included in the appendices at the end of this study.

2.2.1 Growth mindset and instructional Materials

2.2.1.1 Growth mindset induction material. Participants were randomly assigned to either the growth mindset or control condition and performed a reading and writing task (adapted from Blackwell et al., 2007). The task used by the students in the experimental condition is called 'You Can Grow Your Intelligence'. Students read about the malleability of their brain and were asked to explain this concept to other students in the form of a short writing exercise. A short intervention like this was found to be a good way to induce growth mindset (Yeager et al., 2019). Students in the control condition performed a similar reading and writing exercise that doesn't mention the malleability of the brain and is focused on just theoretical information about the brain. The writing exercise asked those students to summarize what they just read. The summaries were analyzed using specific coding words that show that students indeed had connected the mindset intervention materials with learning. Words and word chunks such as 'effort', 'working hard', 'keep on trying' were given a point.

2.2.1.2 Probability instruction material. The learning material was presented in two different videos both teaching probability, differentiating between complexity groups by calculating it with or without replacement. This concept was not taught as part of the primary school curriculum thus all children in primary school are novices in terms of prior knowledge in this topic. Participants were randomly assigned to either a low- or high- complexity condition. Both groups first watched a general introduction and then learned how to solve probability problems by watching a video instruction (adapted from Hoogerheide et al., 2014). The low complexity group learned about probabilities with replacement, the high complexity group learned about probabilities without replacement. Both groups were taught how to calculate two probability exercises. An example screenshot of the low complexity condition (Figure 1) and high complexity condition (Figure 2) is included. Extra screenshots can be found in Appendix B. Videos for both conditions were 7 minutes in length.

Figure 1

Example screenshot learning task low complexity group

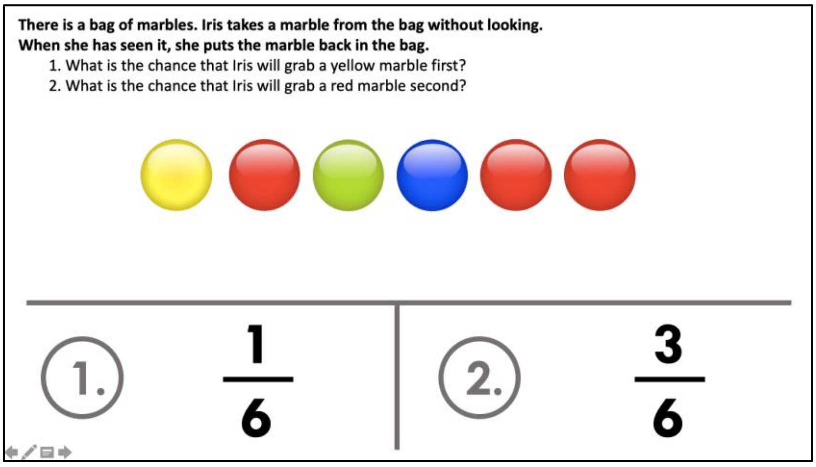
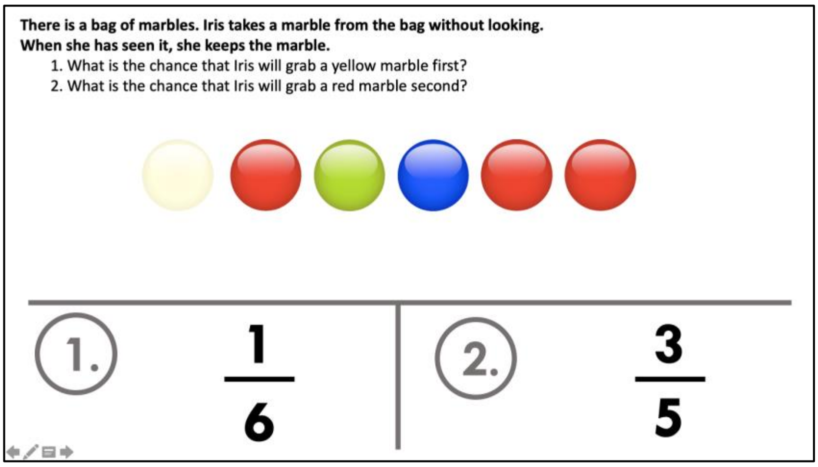


Figure 2

Example screenshot learning task high complexity group



To differentiate between the low and high complexity task, the number of interacting elements were counted. The process of determining the number of elements in a learning material is described by Chen et al. (2015) and starts by estimating the prior knowledge of a learner. When a learner has no prior knowledge, all elements have to be counted separately. When a learner has sufficient schemata for a problem, certain elements can be counted as one. Based on these instructions it was estimated that for the low complexity group 7 elements had to be kept in working memory at the same time, while for the high complexity group this was estimated to be 12 elements (see Table 1). Teachers at the participating schools were consulted to make sure that students had not been taught probabilities.

Table 1

Element Interactivity Count for the Probability Exercise Used in the Learning Task

	Low complexity condition	High complexity condition
Example taught in the video:	There is a bag of marbles. Iris takes a marble from the bag without looking. When she has seen it, she puts the marble back in the bag. The marbles are: yellow, red, green, blue, red, red. *Question 1: What is the probability she takes a yellow marble first?* *Answer 1: 1/6* *Question 2: What is the probability she takes a red marble second?* *Answer 2: 3/6*	There is a bag of marbles. Iris takes a marble from the bag without looking. When she has seen it, she keeps the marble. The marbles are: yellow, red, green, blue, red, red. *Question 1: What is the probability she takes a yellow marble first?* *Answer 1: 1 / (1 + 3 + 1 + 1) or 1/6* *Question 2: What is the probability she takes a red marble second?* *Answer 2: 3 / (1-1 + 3 + 1 + 1) or 3/5*
Element count:	**7 elements in total**: 1 for the yellow marble total. 1 for counting the total amount of marbles. 1 for the total number 6. 1 for calculating the probability. 1 for expressing the probability as a fraction. 1 for the red marble total. 1 for expressing the probability in a fraction.	**12 elements in total**: 1 for the yellow marble total. 1 for counting the total amount of marbles (1+3+1+1). 1 for the total number 6. 1 for calculating the probability. 1 for expressing the probability as 1 / (1+3+1+1). 1 for expressing the probability as a fraction. 1 for calculating that the new total. requires 1 less yellow marble. 1 for calculating the new total. 1 for taking the red marble total. 1 for calculating the second probability. 1 for expressing the probability as 1 / (0+3+1+1). 1 for expressing the probability in a fraction.

2.2.2 Measures

2.2.2.1 Covariate: prior knowledge. Although all participants were expected to be novices regarding knowledge about probability, those better in solving fractions may find it easier to learn about probability. Thus, prior knowledge regarding probability calculations was assessed with two exercises on adding fractions, and two exercises on subtracting fractions. Additionally, four probability problems similar to those taught in the instructional videos were also presented to assess prior knowledge on probability. A sum score of the four fraction and four probability exercises represents prior knowledge. The prior knowledge questions displayed an acceptable reliability (Cronbach's α = .70).

2.2.2.2 Covariate: working memory span. Working memory span was assessed to account for differences in memory span which could cause differences in when working memory is overloaded.

This was assessed using an auditory working memory digit span test adapted from Cowan et al. (2005, 1998). The participants heard an increasing sequence of single-digit numerals ranging from zero to nine, spoken in a male voice. The sequence started with three digits and increased to eight digits. Each digit lasted for about 700 ms. and was then followed by a 700 ms. pause. Following each sequence was a tone that served as a response signal. Each digit chunk was repeated twice (e.g. 234, 958, 4527, 9124). The participants were asked to recall in total 12 sequences of digits and write them down in reverse order. For every correct answer, a point was awarded. A sum of the scores for memory span was calculated. The reliability of this test was acceptable (Cronbach's α = .69). Considering this measure is not on a continuous scale, this reliability is likely underestimated (Kraemer, 1992).

2.2.2.3. Growth mindset. Growth mindset was measured using the Revised Implicit Theory of Intelligence (Self-Theory) Scale. This questionnaire is a revised version of the well-known scale by Dweck (in De Castella & Byrne, 2015). This questionnaire consists of four items on growth mindset (e.g. With enough time and effort I think I could significantly improve my intelligence level.) and four items on fixed mindset (e.g. I don't think I personally can do much to increase my intelligence.). For this study, the participants also completed a second, adapted version that used rewritten questions that were more specifically related to the ability to calculate probabilities (e.g. With enough time and effort, I think I could significantly improve my knowledge of probabilities). The items were scored using a six-point Likert-scale from (1) completely agree to (6) completely disagree. The fixed mindset items were reverse scored, then a mean theory of intelligence score was calculated for the six items. A low score (1) represents a completely fixed mindset, while a high score (6) represents a completely growth mindset. The regular measure (Cronbach's α = .72) and maths-adapted measure both displayed acceptable internal consistency (Cronbach's α = .77).

2.2.2.4 Attribution. Attribution was measured using four self-reporting items adapted from Song et al. (2020). Participants scored two items on their controllability on intelligence (e.g. Intelligence can change if I try to change it.) and two items on effort (e.g. Effort can change if I try to change it). Both variables were scored using a six-point Likert-scale from (1) completely agree to (6) completely disagree. The intelligence measure showed a good internal consistency (Cronbach's α =

.74). The reliability of the effort measure was quite low (Cronbach's α = .53). Because of this attribution on effort was not used for further analysis.

2.2.2.5 Achievement goals. Achievement goals were measured using the Achievement Goal Questionnaire-Revised from Elliot & Murayama (2008). This questionnaire consists of 3 items on mastery-approach goals (e.g. My aim is to completely master the materials presented in this lesson.), 3 items on mastery-avoidance goals (e.g. My aim is to avoid learning less than I possibly could.), 3 items on performance-approach goals (e.g. My aim is to perform well relative to other students.), and 3 items on mastery-avoidance goals (e.g. My aim is to avoid doing worse than other students). The items were scored using a six-point Likert-scale from (1) completely agree to (6) completely disagree. The measure displayed a good internal consistency (Cronbach's α = .76 for mastery-approach goals; Cronbach's α = .80 for mastery-avoidance goals; Cronbach's α = .86 for performance-approach goals; Cronbach's α = .81 for performance-avoidance goals).

2.2.2.6. Cognitive load. Cognitive load perceptions were measured using the Cognitive Load Index scale from Leppink et al. (2013). The questionnaire was adapted to be used with the learning task in this study. The scale consists of 3 items on intrinsic load (e.g. The probability exercises I just made were very complex) and three items on extraneous load (e.g. The probability exercises were full of unclear language). The intrinsic load items from this scale focus primarily on experienced cognitive load during very complex tasks. Both the intrinsic (Cronbach's α = .85) and the extraneous load (Cronbach's α = .71) scales show good internal consistency. The questionnaire does include items on germane load, but as is pointed out by the authors these do not reflect the precise definition of germane load (Leppink et al., 2014). That is why there were four self-developed items added that better fit the definition of germane load (e.g. I could fully understand the concepts covered in the learning task). These showed a good internal consistency as well (Cronbach's α = .77).

Since the Leppink measures were previously mostly used in non-experimental settings, an additional measure, the Naïve Rating Questionnaire from Klepsch et al. (2017) was also used. This measures intrinsic load (e.g. For the video on probabilities, I had to retain many things simultaneously in my mind), extraneous load (e.g. During the video on probabilities, it was exhausting to find the important information), and germane load (e.g. My point while dealing with the video on probabilities was to understand everything correct). All the items were scored using a six-point Likert-scale from (1) completely agree to (6) completely disagree. The components of this measure generally show a quite low internal consistency (Cronbach's α = .60 for intrinsic load, Cronbach's α = .80 for extraneous load, Cronbach's α = .33 for germane load). That is why this measure was not used for further analysis.

2.2.2.7 Performance. Task performance was assessed using probability problems, consisting of 8 problems comparable to the example given in the instructional videos (adapted from Hoogerheide et al., 2014). The exercises consisted of questions where participants were asked to provide two probabilities. For the low complexity group, the exercises are based on calculating probabilities with replacement. The high complexity group made probability exercises without replacement. All the test problems used the same cover story, while only keywords differ for each experimental condition. For every correctly calculated problem a point was awarded. A point could only be obtained if both the numerator and denominator of the fraction were correct. Percentages that were mathematically the same as the correct fraction were also marked as correct (20% is also correct when 1/5th is the correct answer). There were 16 problems in total, which means that the maximum number of points that could be handed out was also 16. This was the same for both conditions. The measure showed a good internal consistency (Cronbach's α = .94).

2.3 Procedure

The experiment was conducted during six data collection sessions with approximately 20 students in each session. Each session took place in the already available classrooms and student year groups that were assigned to that room.

For each session sets of four different envelopes were prepared to contain the materials of the four different conditions: (1) growth mindset-high complexity condition; (2) growth mindset-low complexity condition; (3) control-high complexity condition; (4) control-low complexity condition. Before the experiment began the experimenter randomized the conditions by placing sets of these envelopes on the classroom desks randomly. Each set of the materials was marked with a unique identification number that did not indicate to either the experimenter or the participant in what condition the student participated, thus making it a double-blind experiment. This number was only used to keep track of experimental conditions and did not include any information that could be traced back to the student.

The experiment was conducted in four phases that in total took up about 90 minutes. Each phase was guided by the experimenter to make sure that all participants spent approximately the same time on a task. The participants were instructed to only open a new envelope to take out materials when the experimenter said so.

In the first phase, students filled out general information on their gender, group, and age. Then, working memory span and prior knowledge on fractions and probabilities was assessed. In the second phase, students in the experimental condition read an article and performed a writing task that was designed to induce a growth mindset. The control condition performed a similar assignment that functioned as a control task. After completing the task, students filled out questionnaires on mindset, attribution, and achievement goal orientation. In the third phase, students watched an instructional video on probabilities designed to be either low- or high in intrinsic load. After watching the instructional video, all students filled out questionnaires on cognitive load. After that, students tried to solve eight probability exercises that measured performance.

2.4 Data-analysis

To analyze the results SPSS version 23 was used. To test the hypotheses *t*-tests and ANCOVA were carried out. The dependent variables are attribution, goal orientations, cognitive load, and learning performance. The independent variables are the condition (either experimental or control) and the complexity of the task (low-complexity or high-complexity). The interaction of condition and complexity was analyzed. The variables prior knowledge and working memory span were accounted for as a covariate.

3. Results

Randomization was checked for gender, age and prior knowledge. Using crosstabs analysis, in both the mindset, χ^2 (1) = 0.52, *p* = 0.471, and the complexity condition, χ^2 (1) = 0.58, *p* = 0.448, there was no significant difference found between the different groups regarding gender. The mean age of participants was 10.53 years old (*SD* = .66). Using ANOVA, there was also no significant difference found in age between the four conditions, $F(3, 114) = 0.22$, $p = .881$, $\eta_p^2 = .006$. Further testing also revealed no significant difference in prior knowledge for the four different conditions, $F(3, 114) = 0.15$, $p = .932$, $\eta_p^2 = .004$. In sum, the randomization of the four different conditions was successful. The descriptive statistics were distributed equally across the conditions. Descriptive statistics for all variables can be found in Table 2.

Growth mindset (Hypothesis 1)

The first hypothesis for this study was a manipulation check and stated that participants in the growth mindset condition would report a higher growth mindset and would write more about ‘effort’ and ‘persistence’ than learners in the control condition. A one-way ANOVA was conducted to test this. On average, participants where growth mindset was induced reported a higher growth mindset (*M* = 4.91, *SD* = 0.61), than participants in the control group (*M* = 4.49, *SD* = 0.59. The analysis revealed that mindset of participants significantly differed between the control and growth mindset groups, $F(1, 116) = 14.93$, $p = < .001$, $\eta_p^2 = .114$. The results for this questionnaire were used for all further analyses where growth mindset was included.

For the maths-adapted growth mindset questionnaire, a similar result could be observed. Participants in the growth mindset group reported a higher growth mindset (*M* = 4.95, *SD* = 0.60) than participants in the control group (*M* = 4.70, *SD* = 0.75). This difference was significant, $F(1, 116) = 4.13$, $p = .044$, $\eta_p^2 = .034$.

Coding of the writing assignment showed that participants in the growth mindset condition wrote more about the connection between mindset and effort (*M* = 1,40, *SD* = 1,12) than participants in the control condition (*M* = 0.00, *SD* = 0.00). This difference was significant, $F(1, 116) = 90.12$, p = < .001, $\eta_p^2 = .437$.

Mastery goals (Hypothesis 2)

Hypothesis 2 stated the participants in the growth mindset condition would score higher on mastery-approach and mastery-avoidance and lower on performance-approach and performance-avoidance than participants in the control group. Four two-way ANCOVA's were conducted for mastery-approach, mastery-avoidance, performance-approach and performance-avoidance.

Participants in the growth mindset condition (*M* = 5.06, *SD* = 0.88) scored comparably on a mastery-approach orientation as participants in the control condition (*M* = 5.02, *SD* = 0.73). ANCOVA revealed that the covariates prior knowledge, $F(1, 114) = 0.06$, $p = .806$, $\eta_p^2 = .001$, and memory span, $F(1, 114) = 0.97$, $p = .326$, $\eta_p^2 = .008$, were not significantly related to mastery-approach goals. There was no significant main effect of mindset on a mastery-approach goal orientation after controlling for prior knowledge and memory span, $F(1, 114) = 0.05$, $p = .830$, η_p^2 = < .001

Results on other achievement goals, although not part of the hypothesis, were also analyses. For mastery-avoidance goals, students the growth mindset condition scored slightly higher (*M* = 3.71, *SD* = 1.47) than the control condition (*M* = 3.37, *SD* = 1.54). The covariates prior knowledge, $F(1, 114) = 0.91$, $p = .343$, $\eta_p^2 = .008$, and memory span, $F(1, 114) = 0.65$, $p = .423$, $\eta_p^2 = .006$, were not significantly related to mastery-avoidance goals. There also was no main effect of mindset on mastery-avoidance after controlling for both prior knowledge and memory span, $F(1, 114) = 1.23$, $p = .270$, $\eta_p^2 = .011$.

For performance-approach goals the growth mindset condition (*M* = 3.68, *SD* = 1.33) also scored comparable to the control condition (*M* = 3.68, *SD* = 1.31). The covariates prior knowledge, $F(1, 114) = 0.68$, $p = .410$, $\eta_p^2 = .006$, and memory span, $F(1, 114) = 0.23$, $p = .634$, $\eta_p^2 = .002$, were not significantly related to performance-approach goals. No main effect of growth mindset on performance-approach after controlling for both covariates, could be observed, $F(1, 114) = 0.001$, $p = .972$, η_p^2 = < .001.

For performance-avoidance goals the growth mindset condition (*M* = 3.61, *SD* = 1.54) scored slightly higher than the control condition (*M* = 3.36, *SD* = 1.50). The covariates prior knowledge, $F(1, 114) = 0.47$, $p = .492$, $\eta_p^2 = .004$, and memory span, $F(1, 114) = 0.04$, $p = .836$, $\eta_p^2 = < .001$, were not significantly related to performance-avoidance goals. There were no main effects of growth mindset on performance-avoidance after controlling for both covariates, $F(1, 114) = 0.67$, $p = .413$, $\eta_p^2 = .006$.

Attribution (Hypothesis 3)

Hypothesis 3 stated that participants in the growth mindset condition would have a lower attribution on intelligence than the control condition and a higher attribution on effort than the control condition. The growth mindset condition (*M* = 4.65, *SD* = 0.80) scored slightly lower on attribution to intelligence than the control group (*M* = 4.72, SD = 0.87). ANCOVA revealed that the covariate, prior knowledge, was significantly related, $F(1, 114) = 5.22$, $p = .024$, $\eta_p^2 = .044$, while the second covariate, memory span, was not significantly related to participants' attribution to intelligence, $F(1, 114) = 0.40$, $p = .526$, $\eta_p^2 = .004$. There was no significant effect of mindset on attribution to intelligence, after controlling for prior knowledge and memory span, $F(1, 114) = 0.13$, $p = .721$, $\eta_p^2 = .001$.

Growth mindset and complexity on cognitive load (Hypothesis 4)

Hypothesis 4 stated that for cognitive load, in terms of main effects, the growth mindset condition participants would report lower cognitive load and that the low complexity group would report lower cognitive load. For the interaction between growth mindset and task complexity, the participants who are in growth mindset and higher interactivity group were expected to report lower cognitive load than those in the high complexity control condition. Three two-way ANCOVA was conducted for intrinsic, extraneous, and germane cognitive load.

For intrinsic cognitive load. The covariates prior knowledge, $F(1, 111) = 2.82$, $p = .096$, $\eta_p^2 = .025$, and memory span, $F(1, 111) = 0.14$, $p = .713$, $\eta_p^2 = .001$, were not significantly related to intrinsic cognitive load. Mindset condition/factor included a growth mindset and control group.

Table 2
Descriptive statistics of all variables

	Growth Mindset		Control		Low Task Complexity		High Task Complexity					
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*	skew	kurtosis	min	max
Prior knowledge	2.80	2.29	2.93	2.07	2.97	2.27	2.77	2.09	0.43	-0.72	0.00	8.00
Working Memory Span	5.53	2.36	5.17	2.15	5.59	2.05	5.13	2.44	-0.02	0.12	0.00	11.00
Growth mindset	4.91	0.61	4.49	0.59	4.61	0.67	4.79	0.59	-0.37	-0.44	3.25	5.88
Growth mindset maths	4.95	0.60	4.70	0.75	4.77	0.64	4.89	0.73	-0.68	0.94	2.13	6.00
Intelligence attribution	5.08	0.81	4.76	1.00	4.95	0.84	4.90	1.00	-1.22	2.15	1.50	6.00
Mastery-approach	5.06	0.88	5.02	0.73	4.98	0.87	5.10	0.75	-1.61	4.81	1.00	6.00
Mastery-avoidance	3.71	1.47	3.37	1.54	3.55	1.46	3.54	1.57	-0.02	-1.12	1.00	6.00
Performance-approach	3.68	1.33	3.68	1.31	3.71	1.09	3.65	1.51	-0.27	-0.58	1.00	6.00
Performance-avoidance	3.61	1.54	3.36	1.50	3.59	1.42	3.39	1.61	-0.05	-1.05	1.00	6.00
Intrinsic cognitive load	2.07	0.80	1.93	0.89	2.02	0.85	1.98	0.84	1.00	0.91	1.00	5.00
Extraneous cognitive load	5.12	0.74	5.00	0.90	5.12	0.81	5.01	0.83	-2.05	7.07	1.00	6.00
Germane cognitive load	5.00	0.79	4.95	0.77	5.13	0.69	4.83	0.84	-1.65	5.89	1.00	6.00
Performance	9.15	5.44	9.63	5.34	10.16	5.21	8.65	5.46	-0.38	-1.24	0.00	16.00

Complexity condition/factor included a low and high complexity group. The participants in the growth mindset condition reported a slightly higher intrinsic cognitive load (M = 2.07, SD = 0.80) than participants in the control group (M = 1.93, SD = 0.89). The main effect of growth mindset on intrinsic cognitive load was not significant, $F(1, 111) = 0.67$, $p = .415$, $\eta_p^2 = .006$. Participants in the low complexity condition (M = 2.02, SD = 0.85) reported almost the same intrinsic cognitive load as participants in the high complexity condition (M = 1.98, SD = 0.84). This resulted in a non-significant main effect of task complexity on intrinsic cognitive load, $F(1, 111) = 0.15$, $p = .703$, $\eta_p^2 = .001$. The interaction between growth mindset and task complexity on intrinsic cognitive load was also non-significant, $F(1, 111) = 0.37$, $p = .545$, $\eta_p^2 = .003$.

For extraneous cognitive load, the analyses revealed that both the covariate prior knowledge, $F(1, 111) = 0.88$, $p = .350$, $\eta_p^2 = .008$, and memory span, $F(1, 111) = 0.04$, $p = .852$, $\eta_p^2 = < .001$, were not significantly related to extraneous cognitive load. Participants in the growth mindset condition reported a slightly higher extraneous cognitive load (M = 5.12, SD = 0.74) than participants in the control condition (M = 5.00, SD = 0.90). There was a non-significant main effect of growth mindset on extraneous cognitive load, $F(1, 111) = 0.58$, $p = .448$, $\eta_p^2 = .005$. Participants in the low complexity condition ($M = 5.12$, $SD = 0.81$) reported a slightly higher experienced extraneous cognitive load than participants in the high complexity condition ($M = 5.01$, $SD = 0.83$). There also was a non-significant main effect of task complexity on extraneous cognitive load, $F(1, 111) = 0.51$, $p = .479$, $\eta_p^2 = .005$. The interaction between growth mindset and task complexity on extraneous cognitive load was also non-significant, $F(1, 111) = 0.71$, $p = .400$, $\eta_p^2 = .006$.

For germane cognitive load, both the covariables prior knowledge, $F(1, 111) = 1.80$, $p = .183$, $\eta_p^2 = .016$, and memory span, $F(1, 111) = 0.07$, $p = .797$, $\eta_p^2 = .001$, were not significantly related to germane cognitive load. Participants in the growth mindset condition reported a slightly higher germane load ($M = 5.00$, $SD = 0.79$) than the control group ($M = 4.95$, $SD = 0.77$). There was a non-significant main effect of growth mindset on germane cognitive load, $F(1, 111) = 0.23$, $p = .636$, $\eta_p^2 = .002$. Participants in the low complexity group reported a slightly higher germane load ($M = 5.13$, $SD = 0.69$) than participants in the high complexity group ($M = 4.83$, $SD = 0.84$). There also was a non-significant main effect of task complexity on germane cognitive load, $F(1, 111) = 3.68$, $p = .058$, $\eta_p^2 = .032$. The interaction between growth mindset and task complexity on germane cognitive load was also non-significant, $F(1, 111) = 1.08$, $p = .301$, $\eta_p^2 = .010$.

Growth mindset and complexity on performance (Hypothesis 5)

Hypothesis 5 stated that for learning performance, the growth mindset condition would have higher performance and that the main effect on task complexity might show that low complexity group would have higher performance. For the interaction, the participants who are in growth mindset and high complexity group would report higher performance than those in the high complexity control condition. To test this a two-way ANCOVA was conducted.

The covariable prior knowledge, $F(1, 111) = 0.58$, $p = .446$, $\eta_p^2 = .005$ was not significantly related to performance, while the covariable memory span was, $F(1, 111) = 10.87$, $p = .001$, $\eta_p^2 = .089$. Participants in the growth mindset condition achieved a slightly lower performance score ($M = 9.15$, $SD = 5.44$) than the participants in the control condition ($M = 9.63$, $SD = 5.34$). The main effect of growth mindset on performance was non-significant, $F(1, 111) = 0.54$, $p = .463$, $\eta_p^2 = .005$. Participants in the low complexity condition scores higher on the performance test ($M = 10.16$, $SD = 5.21$) than those in the high complexity condition ($M = 8.65$, $SD = 5.46$). The main effect of complexity on performance was non-significant, $F(1, 111) = 1.38$, $p = .243$, $\eta_p^2 = .012$. The interaction between growth mindset and task complexity on the performance test was also non-significant, $F(1, 111) = 0.68$, $p = .412$, $\eta_p^2 = .006$.

4. Conclusion and Discussion

The present study aimed to give insight on how growth mindset intervention may be implemented in children and what impact it has on their motivation, perceived cognitive load, and performance, under the context of high and low task complexity. This study confirmed that in a randomized controlled setting promoting growth mindset in children leads to a higher experienced growth mindset. There was however no confirmation found for effects of growth mindset on motivation (through attribution or achievement goals), cognitive load, and performance.

Growth mindset induction

Participants in the growth mindset condition reported a higher experienced growth mindset than participants in the control condition. This confirms the first hypothesis of this study and thus shows that growth mindset could indeed be induced in the trial setting. Induction of growth mindset was done through an exercise adapted from Blackwell et al. (2007) called ‘You Can Grow Your Intelligence’. Participants in the growth mindset condition were asked to read a two-page text about the malleability of the brain. After that they completed a writing exercise in which they were asked to write a motivational message to a fellow student using the information they just read. The control group performed comparable reading and writing tasks about an article on the function of the brain. The participants that read about growth mindset showed their understanding of the concept through the writing exercise. These participants successfully connected mindset with learning by writing sentences like ‘You just have to put in more effort to learn more!’ or ‘If you try again eventually you will succeed.’ The present study confirms the notion that a short growth mindset intervention is a successful way of influencing experienced growth mindset (Yeager et al., 2019). In addition to that, the results confirm that this finding is also true for children between ages 10 to 13.

Motivation

Motivation was tested in terms of achievement goal orientation and attribution theory. For achievement goals, the data did not confirm the hypothesis of sub-question two. No significant effects of the growth mindset or control group were found on any of the achievement goals. This is in contrast with the results that Cury et al. (2006) found. In their study growth mindset did significantly predict perceived mastery goals ($\beta = .28$). In a review of studies, Burnette et al. (2013) only found a small significant correlation ($r = .187$) between growth mindset and mastery goals. The finding of the current study suggest that it cannot be definitively said that a causal relationship exists. The results could also indicate that children do not necessarily follow the same thinking processes as adolescents (as researched by Cury et al., 2006) and that specifically for children, growth mindset may not increase motivation through mastery goals. Furthermore, the understanding of goals and attribution in children might not be the same.

Studies like those of Weil et al. (2013) confirm that metacognition, also known as introspection, is an important skill that is important for the understanding of more complex psychological construct such as motivation as perceived by older children and adults. It has been suggested that metacognition undergoes a significant development during the end of childhood and early adolescence. In this stage of developing metacognition, a complex concept such as motivation could be hard to grasp. Especially when that concept has to be translated into scores on a questionnaire that revolves around very specific and sometimes complicated motivational concepts such as mastery-avoidance questions (for example: My aim is to avoid learning less than I possibly could). A suggestion for further research would be to make sure these motivational concepts are appropriate for children and their level of metacognitive skills.

Attribution theory was also used to investigate the relationship between growth mindset and motivation. The results did not confirm the third hypothesis. This was different from earlier effects found by Hong (1999) that participants adopting a fixed mindset attribute significantly more to intelligence than to effort (M = 6.27 vs. M = 2.00, $p < .05$; Study 3), while participants in the growth mindset group did not have a significant difference in attribution on either intelligence or effort (M = 5.47 vs. M = 4.47, *ns*). The current study shows that this effect on attribution at least does not work the same in children. These findings could also be an incentive to perform another replication study to confirm the results Hong et al. (1999) reported.

Task complexity and cognitive load

In the theoretical framework one of the suggested intermediate factors between growth mindset and performance could be a difference in task complexity, which would result in a lower or higher perceived cognitive load. The suggested effects of the hypothesis four was not supported in the data. A difference of five interacting elements between the learning materials for the low complexity group (7 interacting elements) and high complexity group (12 interacting elements) may not be differentiating enough for children to experience a decrease or increase in cognitive load. Even when the interacting elements are more that the seven that can usually be kept in working memory (Sweller et al., 2019). Another factor which could have influenced the load exerted on working memory is that the explanation in instructional video may not be completely the same. For example, there could have caused an increase in extraneous cognitive load in the low complexity group and a decrease extraneous load for the high complexity group which could have resulted in the difference of cognitive load between the two conditions being smaller than was expected.

For future studies that aim to investigate the differentiation between complexity levels, the recommendation would be to perform preliminary research to ensure the design will distinguish bigger differences in the interacting elements between the low and high complexity levels. Indeed, in previous studies into low and high complexity materials, bigger differences in element interactivity can be found. In the first experiment of the study from Chen et al. (2015) the element count for the low element interactivity group was 1, while the element count for the high complexity group was 20, resulting in a 19 element difference between the group. In an earlier study by Tindall-Ford et al. (1997) the low complexity group in the third experiment worked on materials with an element count of 2, while the high complexity group worked on materials with an element count of 16, resulting in a difference of 14 elements. This further affirms the notion that counting elements in a material is not a precise effort, but more of an estimation of the number of elements in a material.

It is also important to point out that the previous research counted element interactivity based on prior knowledge. This makes it more difficult to count the interacting elements, because for students who already know the content the element interactivity count should be one (Chen et al., 2015). The present study recruited participants who are novice in the instructional message. To some extent, this is of more practical relevance to inform instructional design because teachers usually teach new content to students. Thus, future research can better inform the design of task complexity also based on novices, because this is more in line with the practice in an educational context.

Task complexity and learning performance

Learning performance was tested using a task where participants calculated probabilities for problems similar to what they learnt in the instructional videos. The results of this study did not confirm the hypothesis five. There was no difference in performance between either the growth mindset condition or the control condition. Task complexity also had no significant effect on this. This confirms the findings in the review of different studies by Sisk et al. (2018) in which the only effects of growth mindset on performance were found among high-risk adolescents and university students. Most students took part in this study are from higher socioeconomic backgrounds. This may be is in line with previous research that suggested r growth mindset intervention may be only effective for students from disadvantaged background. It should be further investigated if these interventions do benefit children from a lower sociological background in the same way as was found previously in adolescents and university student samples.

4.1 Limitations and future directions

The present study has some limitation. First, due to the Covid-19 pandemic severe lockdown measures were imposed by the national government. This resulted in that the data collection could not be completed as was planned. Before the study, it was calculated that for Cohen's d = 0,5, power = 80%, and type I error rate = 5% a minimal sample size of 128 was needed. The final sample size was slightly less (n = 118) than what was needed to achieve enough power. Although it can be argued that the effect sizes found in the present study are too small for any additional data to have a significant impact on the results, a much bigger sample size might provide sufficient power for some of the effect sizes found in the present study.

Second, attribution was measures using two questions for intelligence attribution adapted from Song et al. (2020). The measure on effort attribution was also included during the data collection. A reliability check of this measure revealed that these questions were not reliable enough to be used in further analyses. There does not seem to be a conclusive way on how to measure attribution successfully and reliably. It is worth investigating how this could be achieved as measuring attribution is something that could prove useful in research on motivation.

Third, while the current study had not found any evidence of growth mindset increasing motivation or learning performance, it has to emphasized that the learning task only consisted out of mathematics exercises. Motivational as measured in this study (attribution and achievement goals) have been, in previous studies, linked to specific subjects. Thus, the engagement of students may differ from subject to subject (Bong, 2004). In future growth mindset studies, it is of interest to also incorporate other subjects than mathematics.

Fourth, while the children in the sample of this study do not seem to have experienced any effect of growth mindset on their motivation or achievement, this study did contain participants that mostly originated from a higher socioeconomic class. This while most growth mindset interventions seem to be the most successful for high-risk students (for example, see Paunesku et al., 2015). Further studies could investigate if this is also true for children with a lower socioeconomic background.

4.2 Implications

The current study has contributed to the existing literature on growth mindset by conducting a randomized controlled experiment with children. While research already suggested that growth mindset has a limited influence on achievement for adolescents and university students (Sisk et al., 2018), the current study suggests that this may also be true for children aged 10 to 12.

This experiment included a manipulation check and showed support for the usefulness of a growth mindset intervention on promoting growth mindset belief. Studies like those of Li & Bates (2017) did not include a manipulation check for growth mindset and thus could not inform the effectiveness of their chosen intervention. This study did and could thus confirm that teaching children a growth mindset does indeed increase their perceived growth mindset.

In the light of the results found in this study, should growth mindset be left all together? The current study seems to indicate that although children did connect thinking about growth mindset to learning, this somehow did not manifest in their motivational and achievement outcomes. This could mean that more research should be done as to how to make the growth mindset intervention materials more suitable for this age group. Otherwise, schools should redirect resources from growth mindset interventions to other more successful interventions that increase motivation and learning. The results of this study cannot also conclusively say that growth mindset is not successful for children in lower socioeconomic backgrounds and leaves room for additional studies to investigate if this can be an intervention that could increase motivation and/or achievement for those students.

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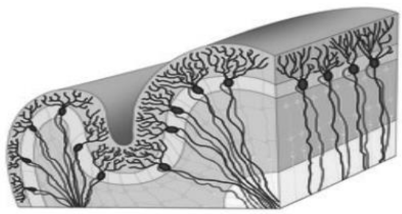
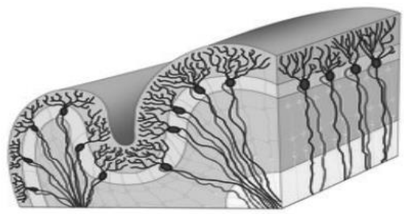
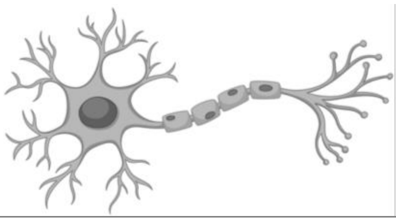
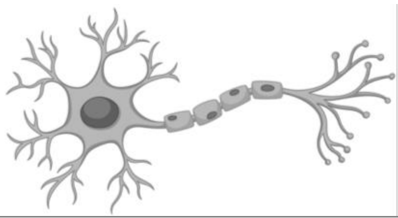
6. Appendixes

Appendix A – Growth mindset intervention and control task

Table 3

English and Dutch Version of the Growth Mindset Intervention (adap*ted from Blackwell et al., 2007)*

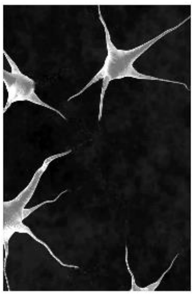
English	**Dutch**
You can grow your intelligence **New research shows that the brain can develop like a muscle** Many people think that the brain is a mystery. These people don't know much about intelligence and how it works. With the word intelligence, many people think that this means that you were born smart, mediocre, or stupid and that this will remain the same for your entire life. New research shows that the brain works more like a muscle that changes and becomes stronger when you use it. Scientists have been able to show how your brain grows and becomes stronger as you learn.	**Je kan je intelligentie laten groeien.** **Nieuw onderzoek laat zien dat de hersenen kunnen ontwikkelen als een spier.** Veel mensen denken dat de hersenen vol geheimen zitten. Deze mensen weten niet zoveel over intelligentie en hoe het werkt. Bij het woord intelligentie denken veel mensen dat dit betekent dat je slim, middelmatig of dom geboren bent en dat dit je hele leven hetzelfde blijft. Nieuw onderzoek laat zien dat hersenen meer als een spier werkt die verandert en sterker wordt wanneer je het gebruikt. Het is wetenschappers gelukt om te kunnen laten zien hoe je hersenen groeien en sterker worden als je leert.
 ***The brain*** When you learn new things, parts of the brain change and get bigger. This is just like muscles. They also change and get bigger when you exercise.	 ***De hersenen*** Wanneer je nieuwe dingen leert, veranderen er stukken van je hersens en worden ze groter. Dit werkt net zoals spieren. Die veranderen ook en worden groter als je sport.
 ***Part of the cerebral cortex*** Inside the outer layer of the brain (the cerebral cortex), there are billions of tiny nerve cells. These nerve cells make connections with other cells. These connections make it possible to thoughts and solve problems.	 ***Stuk van de hersenschil*** Binnenin de buitenste laag van de hersenen (de hersenschors) zijn er miljoenen kleine zenuwcellen. Deze zenuwcellen maken verbinding met ander cellen. De verbindingen maken het mogelijk om te denken en problemen op te lossen.
	

A nerve cell

How do we know that the brain can grow stronger?
Scientists started researching animals. They thought they saw that the brain could change and develop.

They discovered that animals that lived in an environment with a lot of toys and other animals, were much more active than animals that lived in a bare cage. The animals were able to train their brains by playing with toys or other animals.

Effect of a challenging environment



Brains of animals in an empty cage.

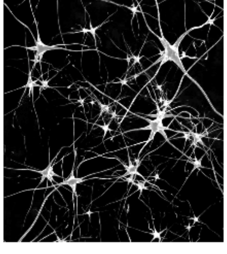
Brains of animals that live with others and have toys.

These active animals had more and stronger connections between their nerve cells in their brains. Their brains were heavier than the brains of the animals that lived in bare cages only. They were also "smarter." They were better at solving problems and learning new things.

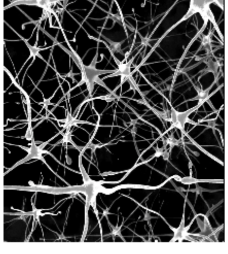
Learning mathematics
Scientists also started looking at children who learn mathematics. They found that children who practice more, and keep working on math problems, also learn more.

Once children have learned to solve a mathematics problem, they won't easily forget it. This is because their brains have changed. This happens because you learn something. The brain cells have grown and new connections have grown between the nerve cells. As a result, the brain has become stronger and smarter.

Growth of the connections between the nerve cells



At birth



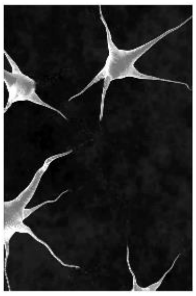
At 6 years old

Een zenuwcel

Hoe weten we dat de hersenen sterker kunnen groeien?
Wetenschappers begonnen met het onderzoeken van dieren. Ze dachten dat ze de hersenen konden zien veranderen en ontwikkelen

Ze ontdekten dat dieren die in een omgeving leefden met veel speelgoed en andere dieren, veel actiever waren dan dieren die in een lege kooi leefden. Die dieren konden hun hersenen trainen door te spelen met het speelgoed of de andere dieren.

Effect van een uitdagende omgeving



Hersenen van dieren in een lege kooi.

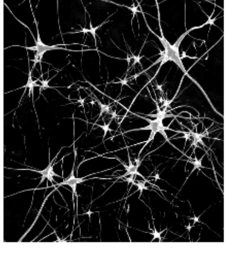
Hersenen van dieren met speelgoed en andere dieren.

Deze actieve dieren hadden meer en sterkere verbindingen tussen de zenuwcellen in hun hersenen. Hun hersenen waren zwaarder dan de dieren die in de lege kooi leefden. Ze waren ook 'slimmer', omdat ze beter waren in het oplossen van problemen en leren van nieuwe dingen.

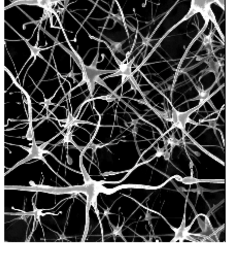
Leren bij rekenen
Wetenschappers begonnen ook te kijken bij kinderen die rekenen leerden. Ze vonden dat kinderen meer leerden als ze meer oefenden, en door bleven werken bij rekenoefeningen.

Wanneer kinderen geleerd hebben een rekenprobleem op te lossen, zullen ze het meestal niet zo snel meer vergeten. Dit komt omdat de hersenen veranderd zijn. Dit gebeurt omdat je iets nieuws geleerd hebt. De hersenen zijn gegroeid en er zijn nieuwe verbindingen tussen de zenuwcellen bij gekomen. Het resultaat is dat de hersenen sterker en slimmer zijn geworden.

Groei van verbindingen tussen zenuwcellen



Bij geboorte

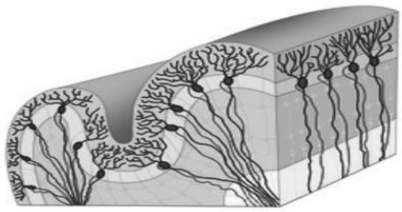
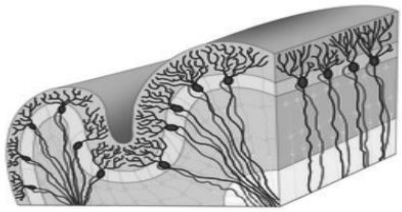
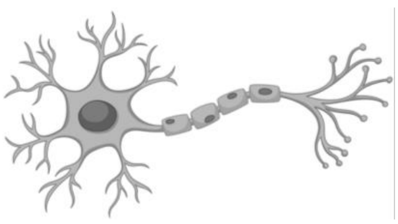
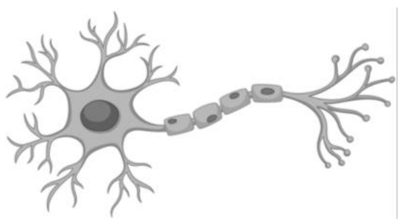


6 jaar oud

When you learn new things, more and more connections are added. These connections are also getting stronger. The more you challenge your brain to learn, the more your brain cells grow.	Wanneer je nieuwe dingen leert, zullen er steeds meer verbindingen bij komen. Deze verbindingen worden ook sterker. Hoe meer je de hersenen uitdaagt om te leren, hoe meer hersencellen er zullen groeien.
As a result, something you found difficult or impossible at first may suddenly seem easy. Think of things like learning to calculate math problems or a new language. The result is a stronger, smarter brain.	Het resultaat is dat iets wat je eerst moeilijk of onmogelijk vond, daarna veel makkelijker is. Je kan dan denken aan dingen zoals het uitrekenen van sommen of het leren van een nieuwe taal. Het resultaat is sterkere en slimmere hersenen.
The key to growing the brain: practice! Students who everyone thinks are "the smartest" are maybe born without being different from others. But perhaps these 'smart' students have already started practicing mathematics before going to school, for example, so that they could already build their math muscles'. Other students might perform just as well on mathematics if they practice as much.	**Het belangrijkst voor het laten groeien van je hersenen: oefenen!** Kinderen waarvan iedereen denkt dat ze ‘de slimste’ zijn, kunnen best geboren zijn zonder dat ze heel anders waren dan anderen. Misschien zijn deze ‘slimme’ kinderen bijvoorbeeld al gestart met het oefenen van lezen voordat ze naar school gingen. Ze hebben dan al aan hun ‘leesspieren gewerkt. Andere kinderen kunnen misschien net zo goed leren lezen als ze evenveel oefenen.
The truth about "smart" and "stupid" Nobody thinks babies are stupid because they cannot solve math problems. They just haven't learned how to do this yet. Still, some call others stupid because they can't solve a math problem, can't spell a word correctly, or read quickly - even though all of these things can be learned through practice. The more you learn, the easier it becomes to learn new things.	**De waarheid over ‘slim’ en ‘dom’** Niemand vindt dat baby’s dom zijn omdat ze geen rekensommen kunnen oplossen. Ze hebben gewoon nog niet geleerd hoe ze dit moeten doen. Toch zijn er mensen die anderen dom noemen omdat ze geen rekensom op kunnen lossen of een woord niet goed kunnen spellen. Dit terwijl je dit kan leren door te oefenen. Hoe meer je leert, hoe makkelijker het wordt om nieuwe dingen te leren.
What can you do to get smarter? Just like an athlete, you will have to train and practice. When you exercise you make your brain stronger. You will also learn skills that allow you to use your brain more smartly.	**Wat kan je doen om slimmer te worden?** Net als een sporter, zal je moeten trainen en oefenen. Wanneer je oefent maak je je hersenen sterker. Je zult ook dingen leren die je helpen om je hersenen beter te gebruiken.
However, many people miss the opportunity to grow their brains more strongly, because they think they cannot, or because it is too difficult. It takes effort, but if you feel yourself getting stronger and better, it's worth it!	Alleen lopen heel veel mensen de kans mis om hun hersenen sterker te maken, omdat ze denken dat ze het niet kunnen of dat het moeilijk is. Het koste moeite, maar als je je hersenen sterker en beter voelt worden, is dat het waard!
Read and carry out the exercise below: You have probably experienced that you found a subject difficult to learn, but that you succeeded after a lot of practice and hard work. You can think of, for example, solving math problems.	*Lees en maak de opdracht hieronder:* Je hebt waarschijnlijk wel eens meegemaakt dat je iets eerst moeilijk vond, maar dat het na veel oefenen, moeite doen en hard werken toch gelukt is. Je kan dan bijvoorbeeld denken aan het oplossen van rekensommen.
What if there was a classmate that thinks a subject is very hard and he/she doesn’t know what to do anymore.	Stel: er is een klasgenoot die iets heel moeilijk vindt en diegene weet niet meer wat hij of zij moet doen.
What would you like to tell him/her? What would you like to say to the person to help him or her? Write that down below:	Wat zou je hem of haar willen vertellen? Wat zou je tegen die persoon zeggen om hem of haar te helpen? Schrijf dat hieronder op.

Table 4

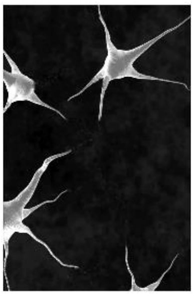
English and Dutch Version of the Control Task.

English	Dutch
The brain is the computer in your head **Through research, we know a lot about the different parts of the brain**.	**De hersenen zijn de computer in je hoofd.** **Door onderzoek weten we al veel over de verschillende onderdelen van de hersenen.**
The brains of humans and animals can be compared to a computer. They regulate everything in your body and you can't do without it. For example, your brain ensures that you don't forget to breathe, remember things, laugh. In short, everything that ensures that you can live.	De hersenen van mensen en dieren zijn te vergelijken met een computer. Ze regelen werkelijk alles in je lichaam. Je hersenen zorgen er bijvoorbeeld voor dat je niet vergeet adem te halen en dat je dingen kunt onthouden. Kortom, alles wat ervoor zorgt dat je kan leven.
In recent years, scientific research has increasingly shown how the brain works. Our brain is very complicated and consists of many brain cells. The number of cells in our brain is comparable to the number of stars in the universe.	Onderzoek heeft de afgelopen jaren zien hoe de hersenen werken. Onze hersenen bestaan uit heel veel hersencellen. De hoeveelheid cellen in onze hersenen is vergelijkbaar met het aantal sterren in het heelal.
 **The brain**	 **De hersenen**
In addition to all cells, there are many connections. It performs very simple, but also difficult tasks. From grabbing a cup of coffee to making plans for the future.	Naast alle cellen zijn er heel veel verbindingen. Daar worden simpele en moeilijke taken mee uitgevoerd. Zoals het pakken van een kopje koffie, tot aan het maken van plannen voor de toekomst.
 **Cerebral bark**	 **De buitenste laag van de hersenen**
Parts of the brain The brain consists of three parts. The first part is the brain stem. This ensures that your heart works, that you can breathe, and that your blood continues to flow. This is all automatic. For example, you never have to think about making your heart beat.	De hersenen bestaan uit drie onderdelen. Het eerste onderdeel is de hersenstam. Die zorgt ervoor dat je hart werkt, dat je adem kan halen en dat je bloed blijft stromen. Dit gaat allemaal automatisch. Je hoeft er bijvoorbeeld nooit over na te denken dat je je hart weer een keer laat kloppen.
 **A nerve cell**	 **Een zenuwcel**

The second part is the cerebellum. They keep your body moving all day long. Your brain also remembers how to swim, cycle, and walk, for example. You hardly have to think about what you are doing with these things.

The third part is the cerebrum. These consist of two halves: the left and right brain hemispheres. The funny thing about this is that your left hemisphere controls the right side of your body and the right hemisphere controls the left side.

Brain cells



Picture of brain cell in babies

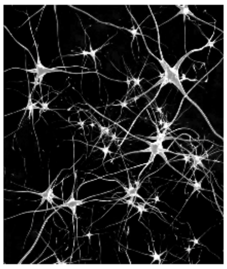
Picture of brain cell in animals.

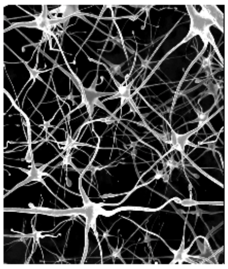
Lobes

The hemispheres of the brain consist of loose pieces. We call these pieces lobes. Each hemisphere has four lobes: the forehead lobe allows you to make decisions, become angry or happy, or make plans. The parietal lobe ensures that you can read, calculate, feel, smell, and taste. The occipital lobe ensures that you can look, move, and recognize things. The sleeping lobe ensures that you understand language, can hear, remember things, and can concentrate.

The nervous system

Brains are made up of nerve cells. These are very small particles of your body that you can only see with a microscope. Nerve cells are not only in your head but throughout your body. These nerve cells together are called the central nervous system.





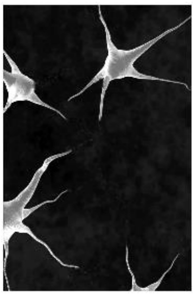
Connections between brain cells

Nerve cells are like small phones. They pass on all kinds of messages to each other. When you handle a hot pan incorrectly, nerve cells work very quickly. They then give a

Het tweede deel zijn de kleine hersenen. Die laten je lichaam de hele dag door bewegen. Ook onthouden je kleine hersenen hoe je bijvoorbeeld moet zwemmen, fietsen en lopen. Je hoeft bij deze dingen bijna niet na te denken wat je doet.

Het derde deel zijn de grote hersenen. Deze bestaan uit twee helften: de linker- en rechterhersenhelft. Door de grote hersenen kan je bijvoorbeeld denken, horen en kijken. Maar dat moet je zelf besturen en gaat niet automatisch, zoals in de kleine hersenen.

Hersencellen



Hersencellen bij Baby's

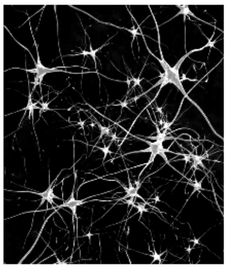
Hersencellen bij dieren

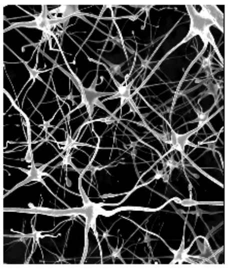
Kwabben

De hersenhelften bestaan uit losse stukken. Die stukken noemen we kwabben. Elke hersenhelft heeft vier kwabben: de voorhoofdkwab zorgt ervoor dat je beslissingen kan nemen, boos of blij kan worden of kan plannen. De wandbeenkwab zorgt ervoor dat je kunt lezen, rekenen, voelen, ruiken en proeven. De achterhoofdkwab zorgt ervoor dat je kunt kijken, bewegen en dingen kunt herkennen. De slaapkwab zorgt ervoor dat je taal begrijpt, kan horen, dingen kunt onthouden en je kunt concentreren.

Het zenuwstelsel

Hersenen bestaan uit zenuwcellen. Dat zijn hele kleine deeltjes van je lichaam, die je alleen met een microscoop kan zien. Zenuwcellen zitten niet alleen in je hoofd, maar door je hele lichaam. Deze zenuwcellen samen heten het centrale zenuwstelsel.





Verbindingen tussen de hersencellen

Zenuwcellen zijn eigenlijk een soort kleine telefoontjes. Ze geven allerlei boodschappen aan elkaar door. Als je een hete pan verkeerd vastpakt werken zenuwcellen heel snel.

message to your hand by letting go right away! We call such a rapid response a reflex. As you read this, your heart is beating, you're breathing, and you're blinking now and then. All brain work. This is also done by nerve cells. You have 100 billion of them. They transmit stimuli from your brain to your little toe and back. The stimuli consist of small streams and chemical substances. These are also called neurotransmitters. **Memory** Some nerve cells specialize in smelling or tasting. Others are more for when you feel pain. Some form your thoughts. You can give other nerve cells commands by thinking, for example, to move your leg. A large portion of your nerve cells go to great lengths to remember things. Together they form your memory. Your memory is divided into a kind of boxes. It is a kind of library. The better you organize this library, the better your memory works. **Brain research** They used to be able to view brains only if someone had died. Fortunately, that is no longer necessary and we can scan the brain. Using devices, doctors can look at pictures of the brain and conduct research. By researching the brain, we have already learned many things. However, we still do not know everything and there is, therefore, plenty that scientists can still research. Hopefully, we will learn more about that big computer in our heads soon.	Ze geven dan een boodschap aan je hand door op meteen los te laten! Zo'n snelle reactie noemen we een reflex. Terwijl je dit leest, klopt je hart, haal je adem en knipper je af en toe met je ogen. Allemaal hersenwerk. Dat wordt ook gedaan door zenuwcellen. Je hebt er 100 miljard van. Ze geven prikkels door van je hersenen naar je kleine teen en weer terug. De prikkels bestaan uit kleine stroompjes en chemische stofjes. Deze worden ook wel neurotransmitters genoemd. **Geheugen** Sommige zenuwcellen zijn gespecialiseerd in ruiken of proeven. Andere zijn er meer voor als je pijn voelt. Sommige vormen je gedachten. Andere zenuwcellen kan je door te denken opdrachten geven, bijvoorbeeld om je been te bewegen. Een groot gedeelte van je zenuwcellen doen veel moeite om dingen te onthouden. Ze vormen samen je geheugen. Je geheugen is opgedeeld in een soort vakjes. Je geheugen lijkt op een soort bibliotheek. Hoe beter je deze bibliotheek indeelt, hoe beter je geheugen werkt. **Hersenonderzoek** Vroeger konden ze hersenen alleen maar bekijken als iemand dood was gegaan. Gelukkig hoeft dat nu niet meer en kunnen we hersenen scannen. Met gebruik van apparaten kunnen dokters kijken naar foto's van de hersenen en zo onderzoek doen. Door onderzoek naar de hersenen te doen zijn we al veel dingen te weten gekomen. Toch weten we nog lang niet alles en is er dus genoeg waar wetenschappers nog onderzoek naar kunnen doen. Hopelijk komen we dus snel nog meer te weten over die grote computer in ons hoofd!
Read and carry out the exercise below: You read a text with a lot of information on the brain. Write a short summery to one of your classmates that explains what you've read. What would you like to tell your classmate? Write it down below:	*Lees en maak de opdracht hieronder:* Je hebt een tekst gelezen met veel informatie over de hersenen. Schrijf een korte tekst aan één van je klasgenoten waarin je uitlegt wat je allemaal gelezen hebt. Wat zou je jouw klasgenoot willen vertellen? Schrijf dat hieronder op:

Appendix B – Learning task intervention

The general introduction plays before both tasks. Included are screenshots of the general introduction and the low and high intrinsic load learning task.

Figure 3

Example screenshot general introduction

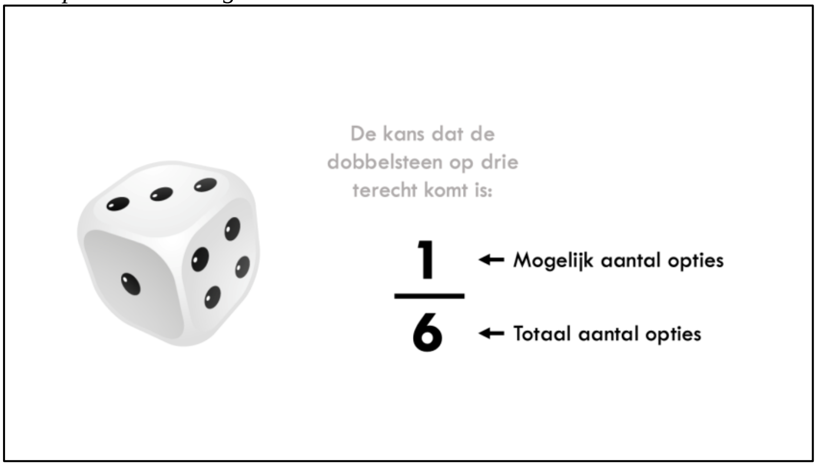


Figure 4

Example screenshot high complexity task (slide 1)

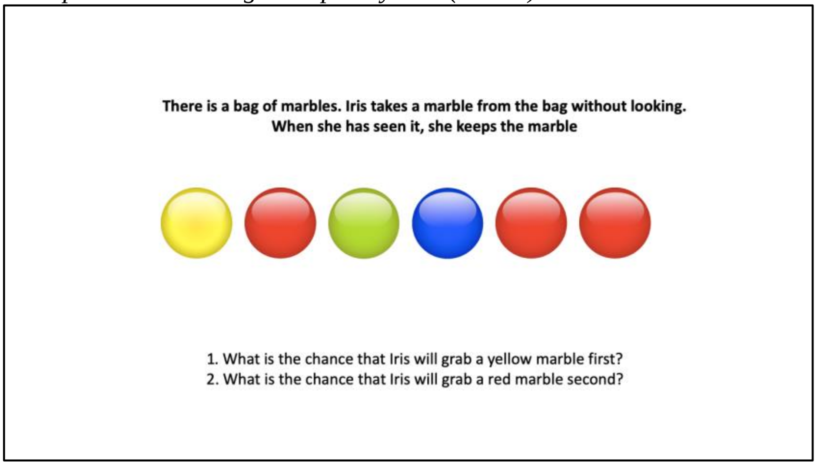


Figure 5

Example screenshot high complexity task (slide 2)

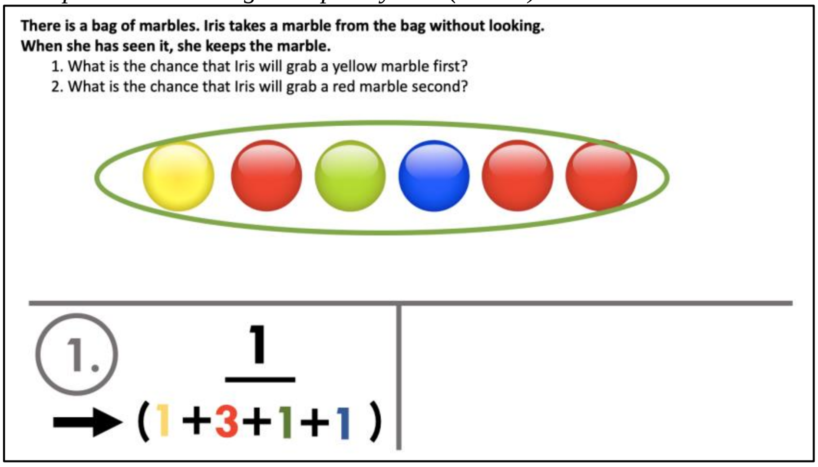


Figure 6

Example screenshot high complexity task (slide 4)

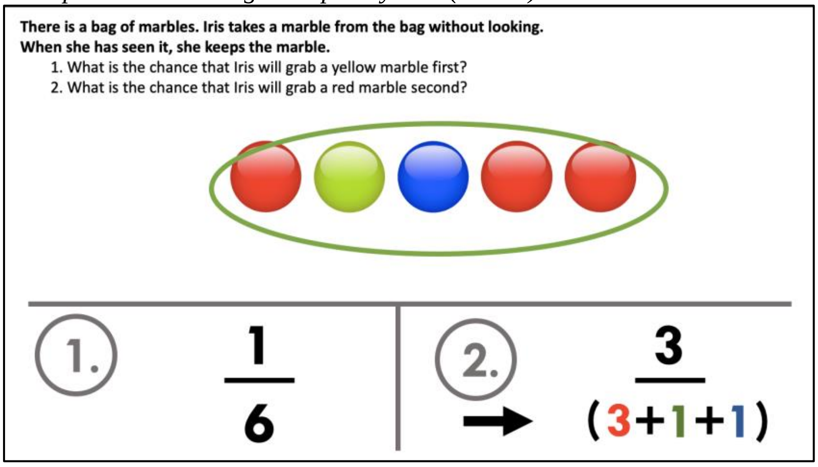


Figure 7

Example screenshot high complexity task (slide 5)

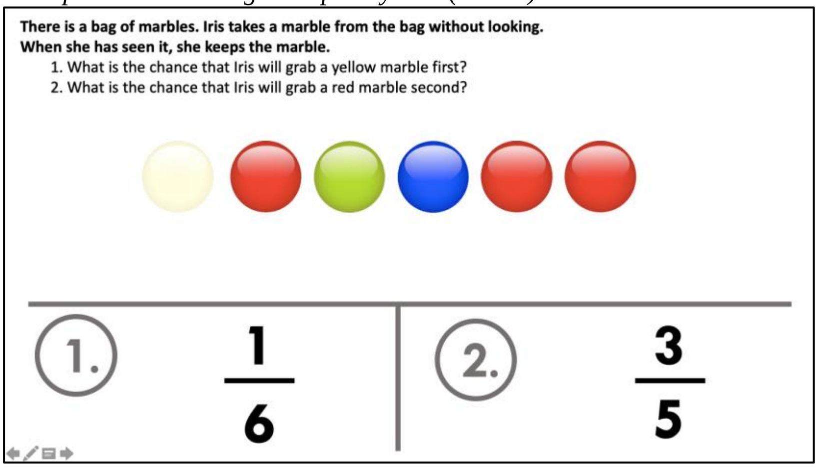


Figure 8

Example screenshot low complexity task (slide 1)

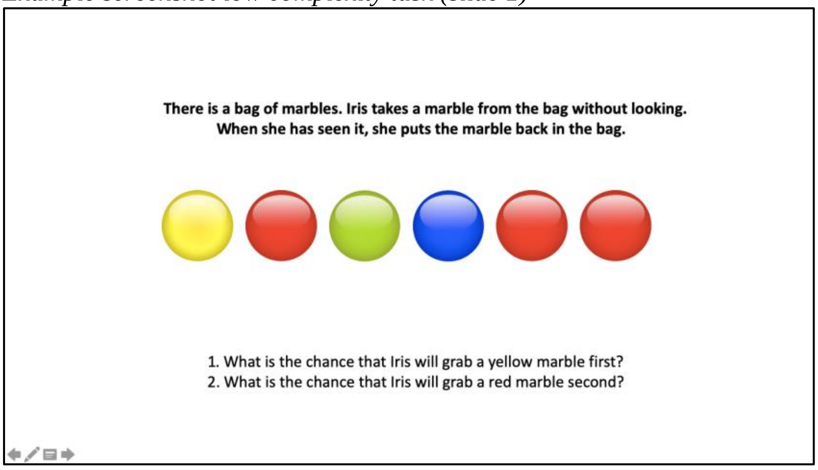


Figure 9

Example screenshot low complexity task (slide 2)

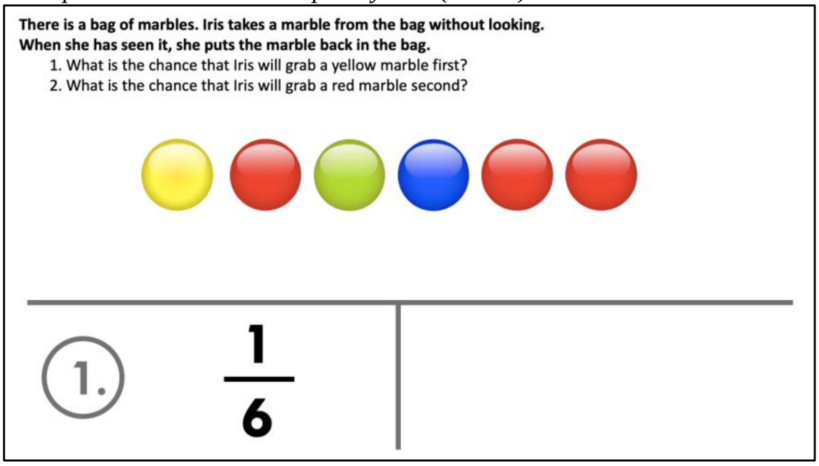
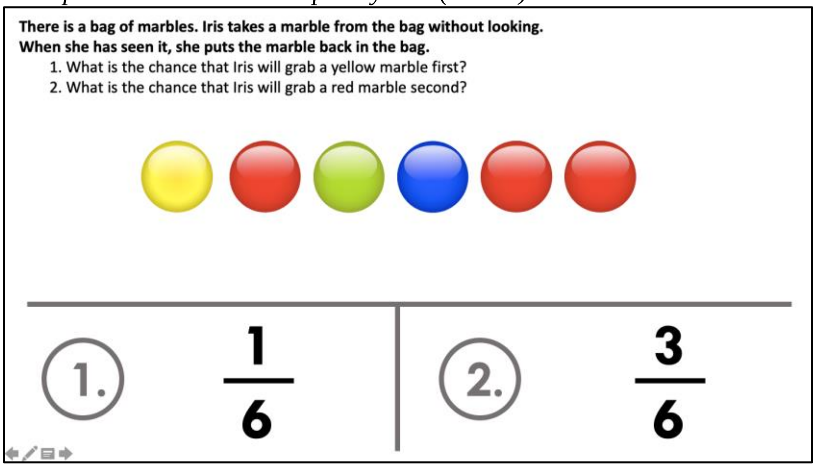


Figure 10

Example screenshot low complexity task (slide 3)



Appendix C – Measures

Table 5
Example questions prior knowledge on fractions

Los op: $\frac{\mathbf{1}}{\mathbf{4}} + \frac{\mathbf{2}}{\mathbf{4}}$
Los op: $\frac{\mathbf{1}}{\mathbf{8}} + \frac{\mathbf{4}}{\mathbf{16}} =$

Table 6
Example question prior knowledge on probabilities

English	Dutch
A soccer team consisting of 11 soccer players (including Noah and Max) shoot a ball taking turns. The coach of the team decides the order in which the players can shoot. *What's the chance that Noah can shoot first, and Max can shoot second?*	Een voetbalteam dat uit 11 voetballers bestaat (waaronder Noah en Max), schiet om de beurt de bal. De coach van het voetbalteam bepaalt de volgorde waarin de voetballers mogen schieten. *Wat is de kans dat Noah als eerste en Max als tweede mag schieten?*

Table 7
Revised Implicit Theory of Intelligence (Self Theory) Scale (De Castella & Byrne, 2015)

English	Dutch
I don't think I personally can do much to increase my intelligence.	Ik denk dat ik persoonlijk niet veel kan doen om mijn intelligentie te laten toenemen.
My intelligence is something about me that I personally can't change very much.	Mijn intelligentie is iets over mij wat ik persoonlijk niet erg kan veranderen.
To be honest, I don't think I can really change how intelligent I am.	Om eerlijk te zijn, denk ik niet dat ik echt kan veranderen hoe intelligent ik ben.
I can learn new things, but I don't have the ability to change my basic intelligence.	Ik kan nieuwe dingen leren, maar ik kan mijn basisintelligentie niet veranderen.
With enough time and effort, I think I could significantly improve my intelligence level.	Met genoeg tijd en moeite, denk ik dat ik mijn intelligentie heel erg kan verbeteren.
I believe I can always substantially improve on my intelligence.	Ik denk dat ik mijn intelligentie altijd heel erg kan verbeteren.
Regardless of my current intelligence level, I think I have the capacity to change it quite a bit.	Het maakt niet uit wat mijn intelligentieniveau nu is, ik denk dat ik de mogelijkheid heb om het best wel te veranderen.
I believe I have the ability to change my basic intelligence level considerably over time.	Ik denk dat ik de mogelijkheid heb om mijn basisintelligentie in de loop van de tijd heel erg te veranderen.

Table 8
Revised Implicit Theory of Intelligence (Self Theory) Scale - Adapted (adapted from De Castella & Byrne, 2015)

English	Dutch
I don't think I personally can do much to increase my maths knowledge.	Ik denk dat ik niet veel kan doen om mijn kennis over rekenen te laten toenemen.
My maths knowledge is something about me that I personally can't change very much.	Wat ik weet over rekenen is iets over mij dat ik persoonlijk niet erg kan veranderen.

To be honest, I don't think I can really change my maths knowledge.	Om eerlijk te zijn, denk ik niet dat ik wat ik weet over rekenen echt kan veranderen.
I can learn new things, but I don't have the ability to change my basic knowledge of maths.	Ik kan nieuwe dingen leren, maar ik kan mijn basiskennis over rekenen niet veranderen.
With enough time and effort, I think I could significantly improve my maths knowledge.	Met genoeg tijd en moeite, denk ik dat ik mijn rekenkennis heel erg kan verbeteren.
I believe I can always substantially improve on my maths knowledge.	Ik denk dat ik mijn rekenkennis altijd heel erg kan verbeteren.
Regardless of my current maths knowledge, I think I have the capacity to change it quite a bit.	Het maakt niet uit wat ik nu over rekenen weet, ik denk dat ik de mogelijkheid heb om het heel erg te veranderen.
I believe I have the ability to change my basic maths knowledge level considerably over time.	Ik denk dat ik de mogelijkheid heb om basiskennis over rekenen in de loop van de tijd heel erg te veranderen.

Table 9

Attribution (adapted from Song et al., 2020)

English	Dutch
Intelligence can change if I try to change it.	Intelligentie kan veranderen als ik het probeer te veranderen.
Intelligence is something that I can change.	Intelligentie is iets wat ik kan veranderen.
Effort can change if I try to change it.	Hoeveel moeite ik doe kan veranderen als ik het probeer te veranderen.
Effort is something that I can change.	Hoeveel moeite ik doe is iets dat ik kan veranderen.

Table 10

Achievement Goal Questionnaire-Revised (Elliot & Murayama, 2008)

English	Dutch
My aim is to completely master the material presented in this lesson.	Mijn doel is om wat ik in deze les moet leren, helemaal goed te kunnen uitvoeren.
I am striving to understand the content of this lesson as thoroughly as possible.	Ik probeer de inhoud van deze les zo goed mogelijk te begrijpen.
My goal is to learn as much as possible.	Mijn doel is om zoveel mogelijk te leren.
My aim is to avoid learning less than I possibly could.	Mijn doel is om te voorkomen dat ik minder leer dan ik kan.
I am striving to avoid an incomplete understanding of the lesson material.	Ik probeer te voorkomen dat ik niet alles uit de les begrijp.
My goal is to avoid learning less than it is possible to learn.	Mijn doel is om te voorkomen dat ik minder leer dan dat mogelijk is om te leren.
My aim is to perform well relative to other students.	Mijn doel is om goed te presteren in vergelijking met mijn klasgenoten.
I am striving to do well compared to other students.	Ik probeer het goed te doen in vergelijking met mijn klasgenoten.
My goal is to perform better than the other students.	My doel is om beter te presteren dan mijn klasgenoten.
My aim is to avoid doing worse than other students.	Mijn doel is om te voorkomen dat het slechter gaat dan mijn klasgenoten.
I am striving to avoid performing worse than others.	Ik probeer te voorkomen dat ik het slechter doe dan anderen.
My goal is to avoid performing poorly compared to others.	Mijn doel is om te voorkomen dat ik slecht presteer in vergelijking met anderen.

Table 11

Cognitive Load Index - Adapted (adapted from Leppink et al., 2013)

English	Dutch
The topic covered in this probability video was…	Het onderwerp in deze video over kansberekening

Not at all complex / very complex	was… *Helemaal niet moeilijk / heel erg moeilijk*
The probability video covered calculations that I perceived as *Not at all complex / very complex*	De video ging over berekeningen die ik ____ vond: *Helemaal niet moeilijk / heel erg moeilijk*
The probability video covered concepts and definitions that I perceived as… *Not at all complex / very complex*	De video over kansberekening ging over onderwerpen en woorden die ik ______ vond: *Helemaal niet moeilijk / heel erg moeilijk*
The instructions or explanations during the probability video were … *Not at all clear / very clear*	De uitleg tijdens de video over kansberekening was… *Helemaal niet duidelijk / heel erg duidelijk*
The instructions and/or explanations during the probability video were, in terms of learning… *Not at all effective / Very effective*	De uitleg tijdens de video over kansberekening werkten voor het leren… *Helemaal niet goed/heel erg goed*
The instructions and/or explanations during the probability video were, full of… *Very unclear language / very clear language*	De uitleg van de video over kansberekening zal vol met… *Heel erg onduidelijke taal/heel erg duidelijke taal*
I could fully understand the concepts covered in the probability video. *Not at all the case / completely the case*	Ik kon de onderwerpen in de video over kansberekening volledig begrijpen *dat is helemaal niet zo /dat is helemaal wel zo*
I could make sense of most of the ideas presented in the probability video. *Not at all the case / completely the case*	Ik kon de meeste ideeën in de video over kansberekeningen begrijpen. *dat is helemaal niet zo / dat is helemaal wel zo*
I could see how all elements described in the probability video are interconnected *Not at all the case / completely the case*	Ik kon zien hoe alle onderdelen die werden beschreven in de video over kansberekening met elkaar te maken hadden. *dat is helemaal niet zo / dat is helemaal wel zo*
I could connect the new information I learnt in this probability video to what I already knew about the topic *Not at all the case / completely the case*	Ik kon de nieuwe informatie die ik in deze video over kansberekening geleerd heb verbinden aan dingen die ik al wist. *dat is helemaal niet zo / dat is helemaal wel zo*

Table 12

Naïve Rating Questionnaire-Adapted (adapted from Klepsch et al., 2017)

English	**Dutch**
For this probability video many things needed to be kept in mind simultaneously.	Voor deze video over kansberekening moest ik veel dingen tegelijk in mijn gedachten houden.
This probability video was very complex	Deze video over kansberekening was heel moeilijk.
I made an effort, not only to understand several details, but to understand the overall context of this probability video.	Ik heb geprobeerd niet alleen de details, maar de hele video over kansberekening te begrijpen.
My point while dealing with this probability video was to understand everything correct.	Mijn punt bij het omgaan met deze video over kansberekening was om alles goed te begrijpen.
During this probability vide, it was exhausting to find important information.	Tijdens deze video over kansberekening was het vermoeiend om belangrijke informatie te vinden.
The design of this probability video was very inconvenient for learning.	De manier waarop deze video over kansberekening gemaakt was, zorgde ervoor dat het moeilijk was om te leren.
During this probability video, it was very difficult to recognize and link crucial information.	Tijdens deze video over kansberekening was het moeilijk om belangrijke informatie te herkennen en koppelen.

Table 13

Performance task examples high intrinsic load (adapted from Hoogerheide et al., 2014)

English	Dutch
Laura has a bag of marbles. She takes a marble from the bag without looking. When she has seen the marble, she keeps it. The bag has the following marble colors: red, yellow, red, yellow, red. a. What is the chance that Laura will grab a red marble first? b. What is the chance that Laura will grab a yellow marble second?	Laura heeft een zak knikkers. Zonder te kijken haalt ze een knikker uit de tas. Als ze de knikker gezien heeft, legt ze die niet terug. In de tas zitten de volgende gekleurde knikkers: rood, geel, rood, geel, rood. a. Wat is de kans dat Laura als eerst een rode knikker pakt? b. Wat is de kans dat Laura als tweede een gele knikker pakt?

Table 14

Performance task examples low intrinsic load (adapted from Hoogerheide et al., 2014)

English	Dutch
Laura has a bag of marbles. She takes a marble from the bag without looking. When she has seen the marble, she puts it back in the bag. The bag has the following marble colors: red, yellow, red, yellow, red. 1. What is the chance that Laura will grab a red marble first? 2. What is the chance that Laura will grab a yellow marble second?	Laura heeft een pot knikkers. Zonder te kijken haalt ze een knikker uit de pot. Als ze de knikker gezien heeft, legt ze die terug in de pot. In de tas zitten de volgende gekleurde knikkers: rood, geel, rood, geel, rood. a. Wat is de kans dat Laura als eerst een rode knikker pakt? b. Wat is de kans dat Laura als tweede een gele knikker pakt?